BEST PRACTICES FOR OPERATORS

by

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ABSTRACT

When working around equipment for a long time, it is easy to become accustomed to it working as it should. It can make us numb to potential problems, especially if they come on gradually. This tutorial will present some techniques that will allow you to detect problems early, and hopefully eliminate downtime and/or reduce maintenance costs. Further, it will give insight into what is in common driven equipment and their drivers. How a centrifugal and positive displacement pump works will be explained in the simplest of terms. Some important relationships of flow, head, and horsepower are highlighted so troubleshooting can be improved.

INTRODUCTION

We will discuss lubrication systems, bearings, drivers, and both centrifugal and positive displacement pumps. The one secret to detecting problems early is to know what "normal" is. The operator is one of the few people that knows how a piece of equipment is supposed to sound, what the pressure normally produced is, and what the equipment feels like when it is doing its job.

Types of Lubrication Systems

- *Splash*—This type of lubrication system is one that usually consists of a reservoir of oil and some part of the spinning shaft and attachment, or the rolling elements of the bearing, that touch the oil and cause it to splash to allow lubrication to take place. There is a place to check the oil level, and it is most important for operators to ensure there is oil.

- *Ring*—This lubrication is accomplished by use of a large ring, usually brass, riding on the turning shaft. It dips down into the oil reservoir and, by viscous drag, brings oil up onto the shaft where it is distributed along the shaft to the bearing. As above there is a place to check the oil level and it is most important for operators to ensure there is oil. There is also usually a place to look at the ring while the piece of equipment is running. This should be viewed often to ensure the ring is turning; if the ring stops, the lubrication will also stop.

- *Circulating*—In this type of lubricating system there is usually a reservoir, a pump, a filter, and it may or may not have a heat exchanger. It supplies oil to the lubricated item at very low or essentially no pressure. It is used when a control flow of clean lubricant is necessary to one or more places that may not be at the same level as the reservoir. It is very similar to a forced-feed lubrication system, but uses its pump to circulate oil only. Check the level in the reservoir and the color of the lubricant. If there are changes, the question "Why?" should always come to mind. If there is a heat exchanger, it should be clean. In Figure 1 the circulating system heat exchanger should be cleaned.

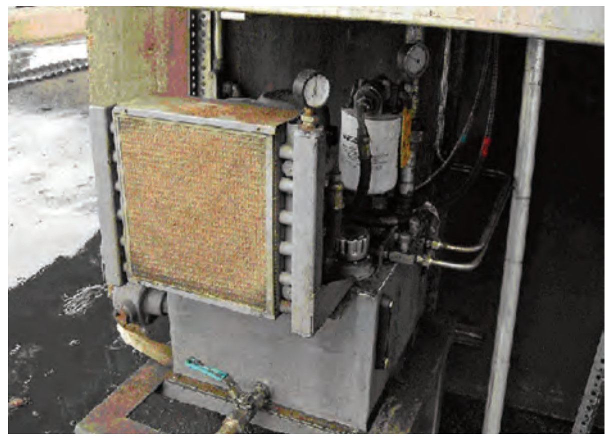

Figure 1. Circulation Oil System.

- *Forced*—This system is very similar to the circulating system but it does operate at a system pressure. It usually has a pressure regulating valve to maintain pressure on the system, and it has coolers, multiple pumps, a pressure regulator, auto start of the stand by pump, filters, and a reservoir. This system is required to remain at pressure, or the equipment it is supplying lubrication to will fail. There are usually safety switches that will cause the lubricated piece of equipment to shut down if the level in the tank falls below a set amount, or if the pressure in the system becomes too low. In addition to the checks of the circulating system, additional checks should be made such as: Are both the main and auxiliary oil pumps running? If so, why? What is the system pressure? Is it normal? Touch the discharge side of the relief valve on the discharge of the pump. Is it relieving? It should not be (refer to Figure 2).

Figure 2. Forced Circulation System.

- *Oil mist*—A system that consists of a tank, tubing, and piping to each item being lubricated, an atomizer, and various safety devices relating to flow and level in the reservoir. With this system there may or may not be a level in the lubricated piece of equipment. There are two general types of mist systems. One is pure mist where there is no lubricant reservoir in each piece of equipment. The other type is a purge mist system where there is a level in the lubricated piece of equipment and oil mist fills the “air” space above the reservoir to control that atmosphere (refer to Figure 3).

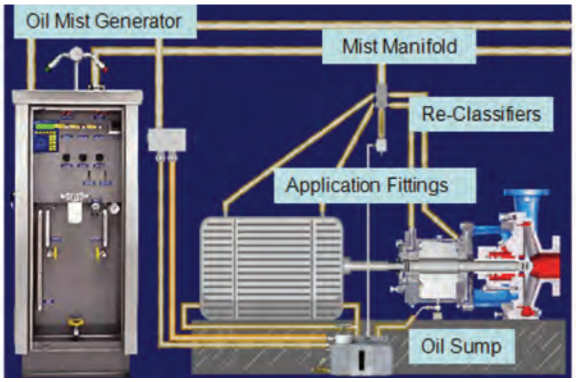

Figure 3. Oil Mist.

- *Automatic grease lubricators*—These are often used to grease inaccessible places. They have a timing mechanism that can be electronic, chemical, or mechanical. They may or may not put out much pressure so they can be prevented from delivering lubricant in some instances. It is important for these lubricators to be marked on their reservoirs with a permanent marker line with the lubricant level and a date as to when the lubricant was at that level. It is one of the few ways to know that lubricant is being put to what is being lubricated. The operator then has a visual reference as to if lubricant is being provided. If the lubricant is being delivered slowly, it should be remarked every few months with a new line and dated to ensure lubricant is being delivered (refer to Figure 4).

Figure 4. Auto Grease Lubricator.

Lubrication

Lubrication is one of the most important aspects of rotating equipment. It is also the neglect of lubrication that causes many pieces of equipment to fail. Lubrication performs the following functions:

- Entirely separates moving surfaces
- Removes heat generated within the bearing and/or from an outside source
- Protects metals from corrosion
- Flushes away contaminants
- Dampens noise

Figure 5 illustrates the difference between full fluid film lubrication with complete separation of surfaces and boundary layer lubrication. Boundary layer lubrication is where there is oil present but not sufficient to keep all surfaces separated and some wear does take place.

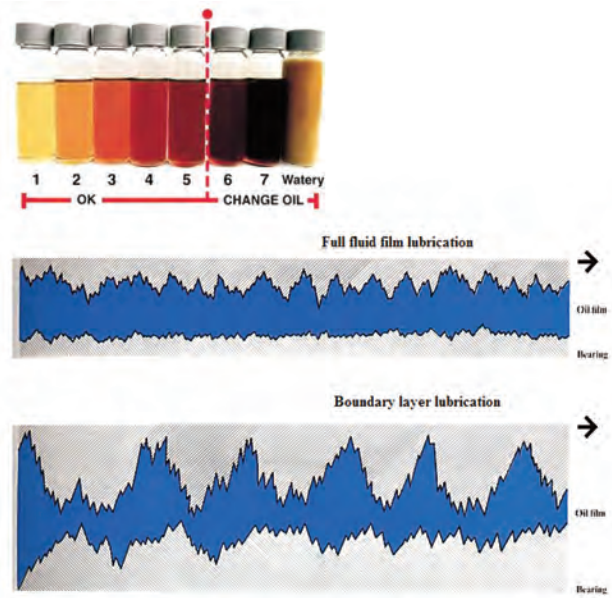

Figure 5. Oil Fluid Film.

From an inspection view it is important to notice the following properties of the lubricant.

- It is important to notice changes in the lubricant, smell, color, and level.
- If the reservoir is small and an oil leak is detected, check the level immediately as not much leakage can be tolerated before the level is dangerously low.
- If the color has changed significantly from yesterday, or what you know to be normal, find out why.
- Ensure levels are maintained. This problem will cause equipment to fail catastrophically in a relatively short period of time if not corrected.
- If the level is increasing, find out why, water may be entering the system. A simple test is to drain some of the lubricant out onto a napkin or paper towel. The oil will be absorbed into the towel but the water beads will stand on the oil soaked towel.

BEARINGS

Plain

These are a general category of simple bearings. They can also be called sleeved bearings and in its simplest form bushings. They consist of a bearing material that is stationary usually and a rotating shaft. They may be lubricated by any of the above methods of lubrication and are a very common bearing, especially in large heavy rotored machines.

One type of plain bearing is called the pillow block bearing. Many of these have water connections going into them for cooling. It normally consists of a water in and water out line on the same side of the bearing and a loop or “U” on the other side. Many times these are rubber hoses and after years exposed to the outside elements they can dry and crack allowing a leak that reduces the cooling water to the bearing. Where these connections enter the pillow block bearing can become poorly sealed, allowing the elements to enter the bearing oil or, if the hose is leaking, the leakage can enter the bearing oil and result in a bearing failure.

Rolling Element

This is a large group of bearings including roller, tapered roller, ball, and needle. They can be lubricated by either grease or oil depending on the manufacturer's recommendations. If a frictionless type of bearing is known to be hot, do not put a water hose on it. The water could get into the lubricant and the cooling water on the outer housing will shrink. The result will likely be the elimination of internal clearances and may cause the bearing to seize immediately. Figure 6 lists numerous bearing types.

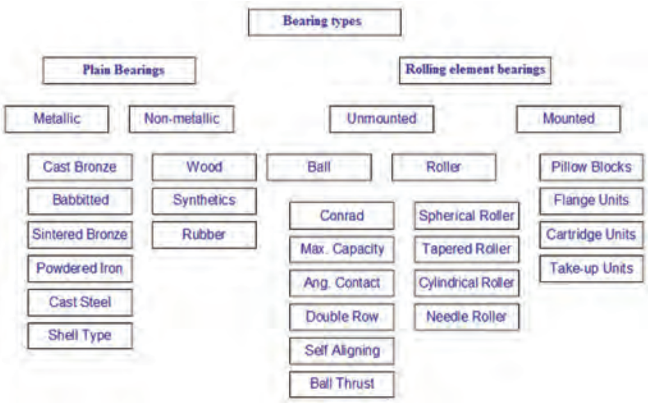

Figure 6. Types of Bearings.

DRIVERS

Motors

This is likely the most common type of driver for not only pumps but many other types of equipment found in industry. They consist of two major components. The rotating element inside the motor is called the rotor and the stationary housing, which is called the stator. The stator has the electrical wiring in it and most industry uses three phase power. From an operations point of view the three phase power means that if any two leads are moved to a new mounting location externally at the connection to the power source, the direction of the motor will be reversed. This is really important because many types of equipment must turn in one direction. That is why the direction of rotation is checked before the coupling is installed between the driver and the driven equipment.

As a general rule, if you touch a motor and it is too hot to keep your hand on, it is likely that it is running too hot. The fins on the outside of a motor are to aid with cooling. These should be clean and clear of debris and insulation. A rule of thumb is that motors that run hotter will likely have a shorter life than one running cooler. There are many factors in determining "too" hot such as the class of insulation and load on the motor at a given time. The best analysis is done by knowing what is normal and detecting a significant change. When the change is noted get additional information as to the significance of the change and that would include help from an acknowledged professional as to insulation type and acceptable upper limit of operation. The motor will not fail immediately as the higher temperatures are reached but running at the higher temperatures is cumulative. It will eventually cause the motor life to be shortened. If you have large motors with an enclosure for outdoors, ensure that the screens or filters that are supposed to be kept clean stay clean. If not, the temperatures will go up and the motor life can be significantly reduced. Figure 7 is a totally enclosed fan-cooled motor (TEFC).

Figure 7. Totally Enclosed Fan-Cooled Motor (TEFC).

Steam Turbines

Steam turbines are another common driver for industrial equipment (Figure 8). They act like the child's pinwheel in the wind. The turbine may have multiple "pinwheels" or stages and the wind is normally replaced by steam. The shafts are sealed by some means of trying to keep the steam from leaking out to the atmosphere. This is done to save the heated and treated water and to keep the steam from going where you do not want it. If the steam seals are leaking badly, it is not uncommon for the steam to enter the bearing housings and condense. The water will return with the oil to the reservoir and since the oil pumps draw near the bottom of the tank eventually, if allowed to continue, the oil pumps will be circulating water or a mixture of water and oil, which are not good lubricants. If visible steam is seen leaking out, the reservoir should be checked to ensure that large quantities of water are not accumulating in the reservoir. Just remember when visible steam is being seen, check lubricant reservoirs to ensure the water is not displacing the lubricant.

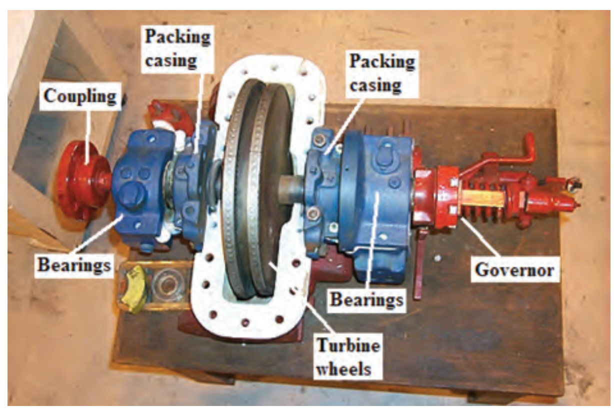

Figure 8. Steam Turbine.

If there is cooling water being supplied to the bearing area, touch the inlet and outlet water lines to ensure heat exchange is taking place or at least flow is taking place. Watch for oil leaks as the oil may collect in the insulation and come in contact with the hot piping or casing and a fire will result.

Notice if the turbine seems to vibrate more when it rains than when the day is sunny. The insulation may allow water to enter and cool the casing in an uneven manner affecting alignment and how smoothly the turbine runs. No one but operators will likely notice the set of cause and effects.

Gearboxes

These are often used when there is a large difference between the speed of the driver and the driven piece of equipment. From an operator or casual point of view the items that are most notable when passing are the sound the gear is making and the temperature and vibration of the gearbox to the touch. This needs to be compared to what it has been, remember we are looking for changes from what is or accepted as normal. Always check foundation bolts by looking for oil being squeezed in and out between the base plate and the foot of the gearbox. Look at the shims as well, do they look like they have been squirming out as this is a potential sign of looseness or high vibration at some time. Figure 9 is an example of a parallel shaft gearbox.

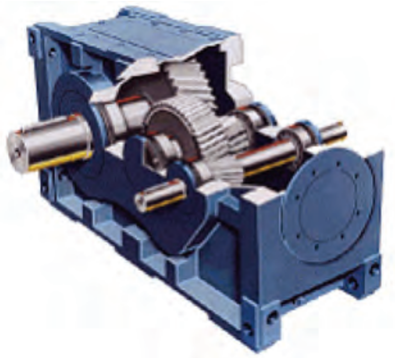

Figure 9. Gearbox.

Heat Exchangers

A heat exchanger is a device built for efficient heat transfer from one medium to another, whether the media are separated by a solid wall so that they never mix, or the media are in direct contact. One of the most common types of heat exchangers in the oil and petrochemical industry is the shell and tube. The fowling will reduce flow and affect the ability of the exchanger to exchange heat. Figure 10 is an example of a shell and tube heat exchanger and Figure 11 is a badly fowled exchanger tube.

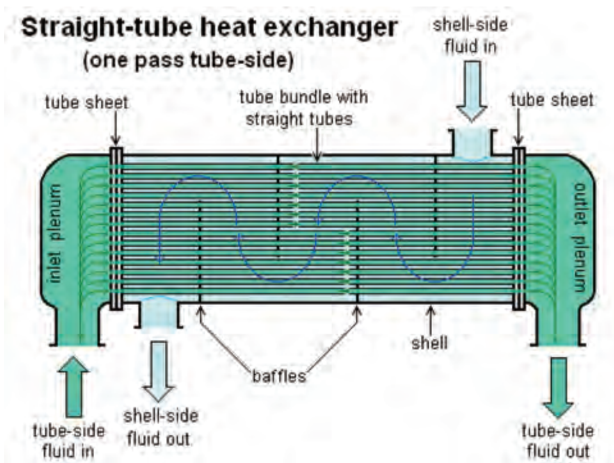

Figure 10. Shell and Tube Heat Exchanger.

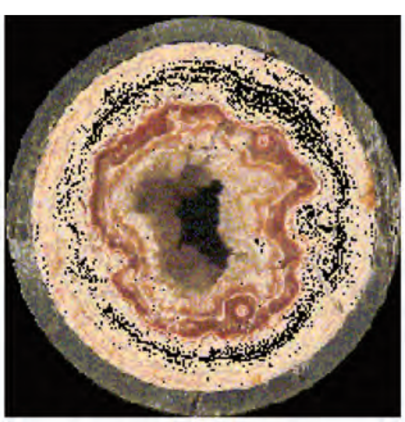

Figure 11. Severely Fowled Exchanger Tube.

DRIVEN

Only centrifugal and positive displacement pumps will be discussed in this tutorial.

Centrifugal Pump

Figure 12 is a generic centrifugal pump. This is one of the most common types of pumps in industry. They can be of the open or closed impeller type and may be single or multiple stages. They use the principal of increasing the velocity of the fluid being pumped and Bernoulli's principal to develop pressure.

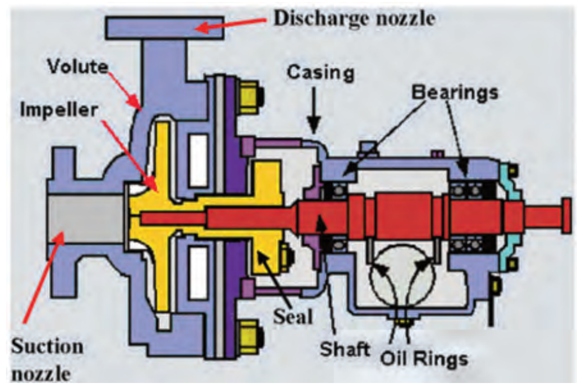

Figure 12. Centrifugal Pump.

These pumps consist of a shaft with bearings for support and an impeller as well as a pump casing and a method of sealing the spinning shaft to keep the liquid being pumped from getting into the atmosphere. The pump has the relationships as listed below.

Some useful relationships to remember in centrifugal pumps are:

- If the pressure is increasing on the discharge pressure gauge, the flow is likely decreasing.
- If the flow is increasing, then the horsepower required is increasing. That can be shown by increasing amps or kilowatts.
- If the viscosity is increasing, the discharge pressure will fall and the horsepower required to pump the fluid will increase.
- If the flow is increasing, the net positive suction head required (NPSHR) will also increase to prevent cavitation.

A typical pump curve is shown in Figure 13.

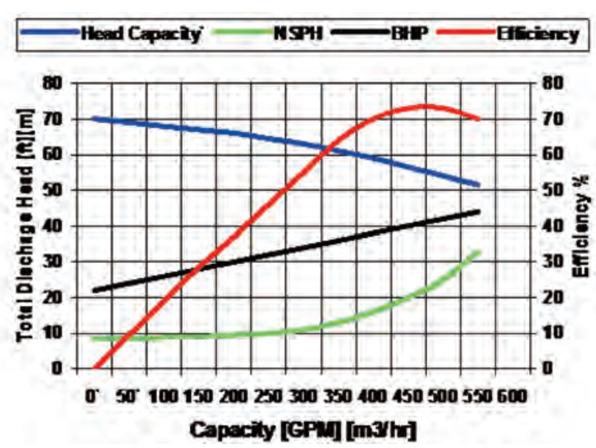

Figure 13. Centrifugal Pump Curve.

Positive Displacement Pumps

A positive displacement pump (Figure 14) is one that, as it turns, liquid is ejected from the pump. As the pump is turned faster more liquid is ejected from the pump. In this pump, flow on the discharge side of the pump must never be stopped as something will be damaged. There are many types of positive displacement pumps but no matter how the pump is configured inside the results are the same. As the pump turns, the liquid must have a place to go.

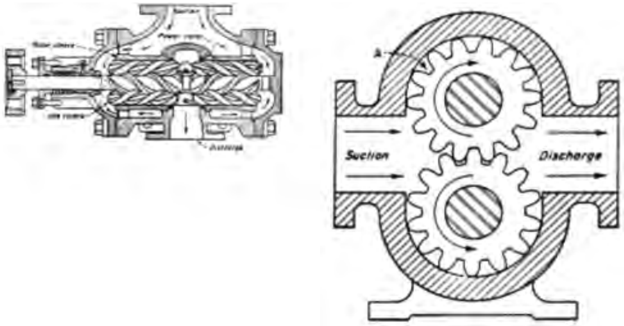

Figure 14. Positive Displacement Pumps.

These pumps have pump curves as do the centrifugal pumps and show much of the same information but they look differently. Figure 15 is a typical positive displacement pump curve.

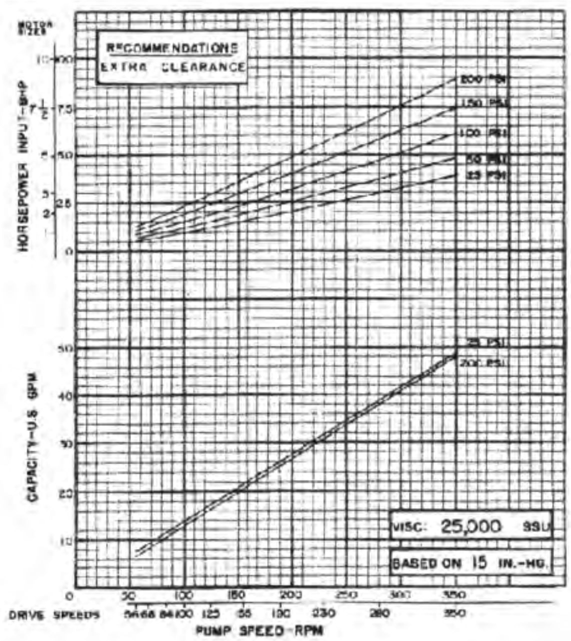

Figure 15. Positive Displacement Pump Curve.

Some useful relationships to remember for positive displacement pumps are:

- If the discharge pressure is rising, the horsepower required to pump is also rising.
- If the pump is required to put out more gallons per minute, then the speed of the pump must be increased.
- If the viscosity of the fluid is increasing, then the horsepower required to pump it is also increasing.
- If the flow is increasing, the NPSHR must also increase to prevent cavitation.

TECHNIQUES AVAILABLE TO OPERATORS AND FIELD PEOPLE

Audible Inspections

These inspections are done during rounds. Listen to the equipment and notice differences over time. In motors a loud hum may mean an internal motor problem of potentially a soft foot condition. If it was quiet yesterday and noisy today, what happened to cause the change? Squealing belts can indicate an overload condition or just loose belts. A scraping sound or rhythmic sound can indicate a dragging or rubbing. A broken tooth on a gearbox may be detected by a clicking or regularly reoccurring sound form inside the gearbox. If a ringing sound is heard, it is important to find the source and ensure that it is not something that will cause a problem with the piece of equipment. Sometimes putting a listening device on a piece of equipment can help identify the source of the sound.

Bad or poorly lubricated bearings can be heard using the audible techniques listed. This is especially useful on frictionless types of bearings. Rubs and other noise producing maladies can be detected in this manner.

Visual Inspections

Look for leaks; look at fluid levels, burned paint, vibrating shafts or housings. Paint burns at about 400 to 450°F (200 to 230°C) and if that is near lubricating oil, then it is likely the oil has gotten that hot as well. That could mean the condition of the oil is no longer viable as a lubricant. Look at motor fan guards for blockage and the fins on TEFC motors to ensure cooling can take place.

Ensure pressure gauges are installed and working. The most accurate readings are when the pressure of interest is between the 10 and two o'clock position on the gauge. It is most important to know what the "normal" pressure is for any piece of operating equipment. Look for signs of over lubrication. This condition will not only make a mess but will shorten equipment life. It is also a potential environmental problem.

If equipment is ring oiled, it is generally easy to look at the ring while the equipment is running. This is a good check because if the ring stops turning for any reason, it has the same effect as the oil pump stopping in a forced lubrication system. There will be no lubrication for the bearings (Figure 16).

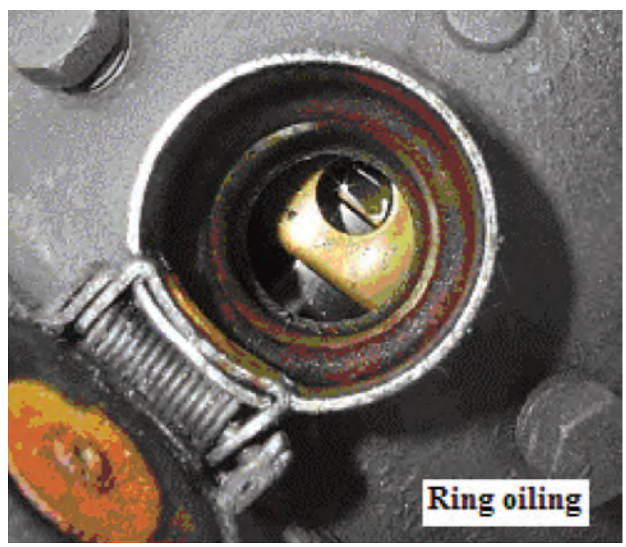

Figure 16. Ring Oil Inspection.

Tactile Inspections

After making sure you will not be burned, touch the equipment. Notice if it feels like tingling in your fingers, which would indicate a high frequency or fast occurring vibration. Is it hot? Hotter than the last time you touched it? Is the hot spot localized or generally hot all over? The temperature on the outside of bearing housings is generally less than the temperature of the bearing itself. The actual temperature of the bearing will be about 30 to 50°F (2 to 10°C) higher than the outside temperature. If a seal pot is used, touch the two lines going to the seal gland. If circulation is taking place, one should be hotter than the other. It is a way to know circulation is taking place. If a pump has multiple filters on it, touching the outlet of the pump and then each filter downstream, it is possible to determine which one is in service. If a pressure relief valve is leaking through, it can be detected by touching the discharge side of the relief valve and the inlet to the relief valve. There should be a difference in the temperatures of the two lines if there is not leakage. If the temperatures are the same, it is likely that the relief valve is leaking.

Lightly touching a piece of equipment with fingertips can give a subjective evaluation of how smooth a piece of equipment is running. With practice it is a reasonably good method of detecting vibration. It must be done regularly as that is the only way to note the changes from yesterday or last week.

Smell

If belts were loose, it may be possible to detect it not only by the sound but also by the smell of the rubber being removed from the side of the belts. Burned oil has a distinct scent that can indicate a potential problem. Paint that gets hot enough to discolor gives a distinctive odor. Each scent may indicate a particular problem with the equipment. Other problems can be indicated if the product being processed in the plant gives a "normal" odor and when there is a problem it gives a distinctly different odor.

The advantages of these types of inspections are:

- Easy to use
- Always available
- Inexpensive
- Can be done by anyone

The disadvantages to these techniques are:

- Subjective
- Difficult to communicate to work request or someone else
- Difficult to repeat
- Problems cannot be detected at their earliest stages of inception.

TOOLS AVAILABLE TO IMPROVE DETECTION OR QUANTIFY WHAT YOUR SENSES DETECT

Audible

Ultrasonic Gun

This is a relatively inexpensive device for listening to noises in the ultrasonic range. It is sometimes used in leak detection and sometimes for listening to bearings.

Stethoscope

This is an inexpensive tool that can pick up every sound that the equipment is making. It must be used regularly or it is impossible to determine if there is a problem or not. The good news is that it picks up everything, and the bad news is that it picks up everything.

Screwdriver

A steel or aluminum rod can be used to touch the piece of equipment where the suspected noise is and the other end touched to the ear to listen for unusual noises. The end touching the ear should be padded and the other end kept away from rotating shafts.

Valve Wrench

A valve wrench can be used in the same way as the other techniques to get the sound of what is happening inside a piece of rotating equipment.

Hard Hat

Even a hard hat can be turned on edge and touched to the equipment and the other end touched to the ear to listen for potential problems inside the rotating piece of equipment.

Visual

IR Gun

The infrared (IR) handheld noncontact temperature measuring device is an easy tool to use if it is used within its limitations. The limitations are that many IR guns use a laser pointer to tell where you are aiming the device. The area the device looks at is cone shaped and the laser is at the center of the cone (Figure 17). That means the further away from the item of interest you are, the more surface area will be averaged into the reading. The laser spot does not represent the measurement area of the device. The first surface that the device sees is the one that will be measured. You cannot measure the temperature of something behind a glass or plastic cover as that cover will be what is measured. If correct temperatures are important, the device must be used on flat dark-colored objects. It will give very low readings on shiny objects.

Figure 17. IR Gun Cone of Average.

The best use of the device is to mark a black paint spot on the areas of interest and use the infrared gun, as close as possible at that spot. It is the only way to get useful repeatable readings.

IR Camera

These devices are similar to the handheld guns but are like looking through a camera. The objects look gray with a color scale range showing different temperatures. What appears to have no problem with the naked eye will show very differently with the infrared camera. Typical pictures of what the eye can see and what the infrared camera can see are illustrated in Figure 18.

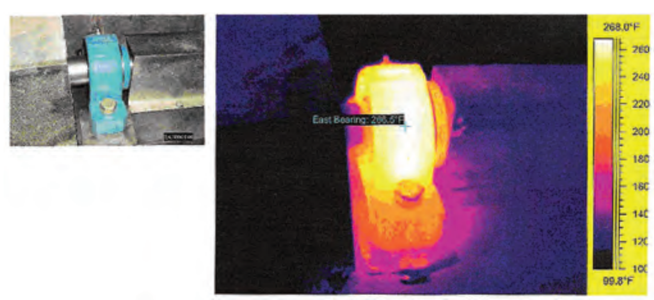

Figure 18. IR Camera Picture.

Strobe Light

This device has a high intensity light that can be controlled to a specific flash rate (Figure 19). When an object is turning at a specific speed and the strobe flash rate is tuned to the same flash rate the moving object appears to be stopped. A good visual inspection can be done while a piece of equipment is turning at running speed. Things like broken shim packs in couplings, missing keys, or broken fans on electric motors can all be inspected without having to stop the piece of equipment.

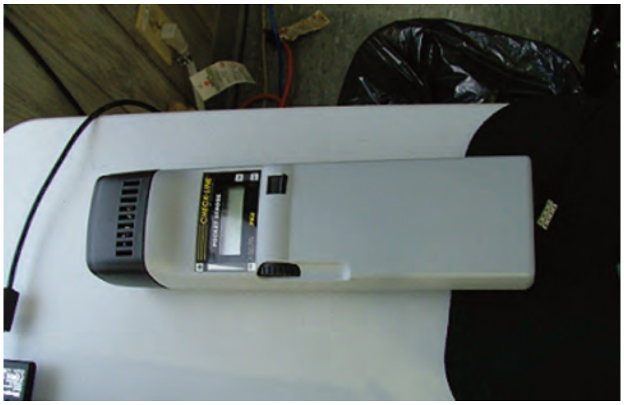

Figure 19. Pocket Strobe Light.

Tactile

Vibration Equipment

A handheld vibration meter can be used to get overall readings. The use of equipment to augment the five senses is useful because it is objective and not subjective. Everyone that uses the equipment and measures in the same place will get the same number. If 50 people touch the same piece of equipment in the same place, there are likely to be 50 different interpretations of how much vibration there is. This is also true for how hot a piece of equipment is.

If quantitative analysis is required, a contact parameter is an inexpensive and accurate tool for temperatures. It is simple to use and will give repeatable results no matter what color the surface being measured is.

GUIDES FOR OPERATORS TO INSPECT EQUIPMENT

These types of inspections can be generated for all types of equipment, such as fans, compressors, extruders, turbines, motors, conveyers, elevators, etc. This list is limited to centrifugal and positive displacement pumps, gearboxes, motors, heat exchanger, and turbines.

Pump Inspections

1. LOOK at the pump as you walk up.
   - Is it shaking?
   - Smoking?
   - Is the discharge pressure different today than yesterday?
   - Are all of the anchor bolts in place? Are they tight?
   - Are there any indications of leakage of fluids of any kind?
   - Are there vibrating parts on the pump that have come loose?
   - Look at the motor amps. Pump capacity problems do not cause the motor to pull excessive amps.
   - Is the seal leaking?
   - Is there proper level in the seal pot ,if used?
   - Is there coupling spacer dust on the foundation? Pieces of shim pack?
   - Is the discharge pressure gauge steady? (If not, there may be cavitation.)
   - Is the oil level in the bearing housing correct? Discolored?
   - Is oil pressure correct for the pump?
   - Is delta-P on oil filter low? High? Why?
   - Is paint burned off in new places? Why? (Paint discolors around 400 to 450°F/200 to 230°C)
   - Look at the vibration monitor on a regular basis.

2. LISTEN to the pump.
   - Is it noisy? Bearings? Cavitation?
   - Does it sound different today than yesterday? Is the noise the motor or the pump?
   - Is the noise constant or changing? (May be a control valve opening and closing.)
   - Does it sound like gravel inside of the pump casing? (Cavitation)
   - Are there steam, air, or gas leaks in or near the pump?
   - If used, are the drive belts squealing? Belts loose?

3. FEEL—Touch the pump with finger tips.
   - Is it warm, hot, cold?
   - Is it different than it was yesterday? How and why is it different than yesterday?
   - Is it shaking more than yesterday? Is it too much?
   - Is the auxiliary oil pump running, if it has one? Why?
   - Is the oil relief valve dumping oil? Why?
   - Is the pump vibrating? Same as yesterday?
   - Is the bearing housing hot? (May be too much oil or bad cooler)
   - Touch the seal lines; is there a difference in temperature indicating flow?

Motor Inspections (Mechanical)

1. LOOK at the motor as you walk up.
   - Is it shaking?
   - Is it smoking or sparks flying?
   - Is there anything loose, shaking, or vibrating on the motor?
   - Is the flex conduit in good condition or broken?
   - Has the dust cap come off of the bearing on the coupling end of the motor.
   - Is the fan on the TEFC motor turning?
   - Are the air filters or fins on a TEFC motor clear so air can circulate?
   - Is there any paint burned on the motor? If yes, why and where?

2. LISTEN to the motor.
   - Is it noisy? Bearings? Fan?
   - Does it sound different today than yesterday?
   - Is the noise the motor or the driven piece of equipment?
   - Is the noise constant or a rhythmic hum?
   - Are the belts slipping on the drive end of the motor?

3. FEEL—Touch the motor.
   - Is it warm, hot, cold?
   - Is it different than it was yesterday? How and why is it different than yesterday?
   - Is it vibrating?
   - Is the fan turning and putting out air?
   - Is the cooling system for the motor and/or lubrication system functioning correctly?

Gearbox

1. LOOK at the gearbox as you walk up.
   - Is it shaking?
   - Smoking?
   - Are all of the anchor bolts in place? Are they tight?
   - Are there any indications of leakage of fluids of any kind?
   - Are there vibrating parts on the gearbox that have come loose? (Coolers? Bearing caps?)
   - Is there water in the oil?
   - Is the auxiliary pump running? Why?
   - Is the oil pressure correct?
   - Is the oil cool enough? Is the cooler working?
   - Is the oil level correct in the sump?
   - Are there coupling pieces on the pedestal under the coupling guard?
   - Is the delta-P for the oil filter high? Why?
   - Check the vibration readings if continuously monitored.

2. LISTEN to the gearbox.
- Is it noisy?
- Does it sound different today than yesterday?
- Is the noise constant or changing?
- Are there steam, air, or gas leaks in or near the gearbox?

3. FEEL—Touch the bearing housings with your finger tips.
- Are they excessively hot?
- Is it different than it was yesterday? How and why is it different than yesterday?
- Is it shaking more than yesterday? Is it too much?
- Is the oil pressure relief valve bypassing oil? If so, why?
- If there is an oil cooler, is heat being exchanged? Touch the inlet and outlines to ensure heat is being removed.

Turbine Inspections

1. LOOK at the turbine as you walk up.
- Is it shaking?
- Smoking? There may be an oil leak and fire potential.
- Are all of the anchor bolts in place? Are they tight?
- Are there any indications of leakage of fluids of any kind?
- Are there vibrating parts on the turbine that have come loose? (Coolers? Bearing caps?)
- Is steam leaking out of the glands that seal the shaft to the casing?
- Is there water in the oil?
- Is the governor hunting? (A continuous speeding up and slowing down in speed.)
- Are the steam traps near the turbine working?
- Is the auxiliary pump running? Why?
- Is the oil pressure correct?
- Is the oil cool enough? Is the cooler working?
- Look at the vibration readings for the turbine; are they steady and low? If not, why?
- Is the oil level correct in the sump? In the bearing boxes?
- Are the ring oilers turning or hung up?
- Is there steam leaking out of the stem of the control valve?
- Is the air purge turned on for the bearings to keep steam out of the oil?
- Are there coupling pieces on the pedestal under the coupling guard?
- Is the governor hunting?
- Is the trip mechanism resting on its knife edge?
- Is the delta-P for the oil filter high? Why?
- Check the vibration readings, if continuously monitored.
- Look at piping support springs to ensure that blocks were not left in after maintenance, especially if a hydro were performed on the piping system.
- Look at the coupling area and see if there are shims from the spacer or dust if an elastometric type of coupling is used.

2. LISTEN to the turbine.
- Is it noisy? Steam leaking?
- Does it sound different today than yesterday?
- Is the noise constant or changing? Is the governor steady or hunting.
- Is there steam, air, or gas leaks in or near the turbine?

3. FEEL—Touch the turbine bearing housings with your finger tips.
- Are they excessively hot?
- Is it different than it was yesterday? How and why is it different than yesterday?
- Is it shaking more than yesterday? Is it too much?
- Is the oil pressure relief valve bypassing oil? If so, why?
- Check oil cooler to ensure it is removing heat from the oil.

Heat Exchanger Inspections

1. LOOK at the heat exchanger as you walk up.
- Is it shaking?
- Are all of the anchor bolts in place? Are they tight?
- Are there any indications of leakage of fluids of any kind?
- Is the differential pressure correct?
- Is heat being exchanged in the cooler? Touch the inlet and outlet and ensure there is a difference in temperatures.
- Is the delta-T for the exchanger normal?

2. LISTEN to the exchanger.
- Is it noisy?
- Does it sound different today than yesterday?
- Is the noise constant or changing?
- Is there the sound of gas or boiling going on inside?

3. FEEL—Touch the exchanger with your finger tips.
- Is it excessively hot?
- Is it different than it was yesterday? How and why is it different than yesterday?
- Is it shaking more than yesterday? Is it too much?
- Touch or test the inlets and outlets of the exchanger to see if an exchange is taking place.

General Equipment Start Up

These instructions are very general and should be performed for the driver and the driven equipment.

Inspection

- Check and start all auxiliary system. That would include lubrication, seal, and cooling systems as they apply.
- Ensure there are adequate liquid levels in all areas that have liquids. That is sumps, lubricators, greasers, and barrier or buffer systems, etc.
- Look at the condition of the lubricant. Color changes especially if they happen rapidly or are not normal for this piece of equipment should be investigated prior to starting.
- If this equipment operates hot, allowances must be made for warm up to allow all parts to come to temperature. A rule of thumb is to allow the pump temperature to rise at 100 per hour.
- If the pump uses a double seal or other arrangement that has a cooler, ensure the cooler is functioning by touching the inlet and outlet parts to ensure that heat exchange is taking place.
- If there is a device such as a guided slide, or flex plate as on steam turbines, it must be free to allow movement or flexing as temperatures rise from ambient. The same is true for extreme cold temperatures.
- On motors ensure ventilation openings are clear of obstructions that could restrict airflow.
- Ensure the area around the equipment is clean and free of hazards.
- For motors verify there are no loose conduit or cable connections or broken conduits. Ensure all foundation bolts are tight.
- Ensure that all valves are in the proper position.
- If there are site-specific or manufacturer-specific instructions, they must be followed.
- Start the equipment.
- Perform operational checks after startup.

General Equipment Shut Down

These instructions are very general and should be performed for the driver and the driven equipment.

Inspection

- If this equipment operates hot, allowances must be made for cool down to allow all parts to come to temperature and oil left circulating long enough to ensure the bearings will not be damaged.
- Look at the condition of the lubricant prior to shut down while it is still circulating. Color changes especially if they happen rapidly or are not normal for this piece of equipment should be investigated.
- Ensure there are adequate lubricant levels in all areas that have lubricant. That is sumps, lubricators, greasers, etc.

- If there are site-specific or manufacturer-specific instructions, they must be followed.
- Stop the equipment.
- Stop the auxiliary systems, again to include lubrication, seal systems, and cooling. If rotors are extremely hot (above 250°F/120°C), allow the lubricating system to circulate to cool the shaft and bearings. This is especially necessary if the bearings are made of babbited material.
- If the equipment has a cooler to regulate temperatures, it is ideal to have a method of backflushing the cooler. This should be done at each opportunity such as shutdown or equipment swaps.
- Ensure ventilation openings are clear of obstructions that could restrict airflow. If they are obstructed, see that they are cleared before the next use. If the motor has filters, look at the condition of the filters and have them changed if they are dirty before the next start.
- For motors verify there are no loose conduit or cable connections or broken conduit. Ensure all foundation bolts are tight.
- Perform a visual inspection for leaks after shutdown.

CONCLUSION

While appearing elemental the list of inspection items, explanation of equipment, and important relationships is essential to good equipment operation and longevity. It is not unusual for people to accomplish these tasks away from work but are not always practiced at work as an operator. The simple techniques of touching, listening, and visually inspecting equipment while on rounds or passing by equipment will ensure the best life possible for equipment and reduce the likelihood of unexpected failures.